4.3 Families of Requirements

Text for Chapter 4.3

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Families of CSP test specifications.

Overview of Chapter 4.3

- feature-oriented description
- the CoRE method
- families of CSP-OZ specifications
- families of CSP test specifications

Focus on Requirements

- motivation:
  - ○ all feature interaction problems already (implicitly) present in requirements
  - ○ many "formal methods" support single product only
    - ▷ how to integrate family support into method?

Feature-Oriented Description in Telephone Switching

- base description plus separate feature descriptions
- attraction: behavioural "modularity"
  - ○ easy change of system behaviour
  - ○ make *any* change by just adding a new feature description
  - ○ never change existing descriptions
- emphasizes individual features
  - ○ makes them explicit
- de-emphasizes feature interactions
  - ○ makes them implicit in the feature composition operator

- not all feature interactions are bad
  - ○ feature-oriented description relies on the good ones
- example: busy treatments
  - ○ B_1 and B_2 both enabled, B_2 higher priority
  - ○ B_1 not applied, despite its stand-alone description
  - ○ behavioural "modularity": add new busy treatments without changing existing ones
- most feature-oriented descriptions still informal
  - ○ behavioural "modularity" and formality do not combine easily
    - ▷ behavioural "modularity": don't answer some questions now
    - ▷ formality: answer all questions now
  - ○ proposed composition operators / approaches often do not scale

- IP telephony:
  - ○ highly complex new services
  - ○ services still viewed as stand-alone
  - ○ undesired feature interactions will haunt us soon

Feature-Oriented Descriptions and Common Abstractions

- modules need common abstractions/assumptions
  - module: now in the sense of this lecture
  - common abstraction/assumption: true for *all* family members
- rapid innovation, legacy systems, too many players: hard to limit the domain
- *without domain limits: no common abstractions*

Performing Incremental Specification Formally

- standard means:
  stepwise refinement
- step:
  1. extend behaviour *or* 2. impose constraints
  - example 1.: add another potential event to a state
  - example 2.: specify the order of two events
- interesting properties preserved by step
  - example 1.: all old events remain possible
    - ▷ no deadlock in this state
  - example 2.: no harmful event added
    - ▷ all safety properties preserved

Non-Monotonous Changes

- telephone switching:
  new features change the behaviour
  - of base system, or
  - of other features
- example: call forwarding
  - stops to connect to dialled number
    - ▷ restricts base system behaviour

    and
  - starts connecting to forwarded-to number
    - ▷ extends base system behaviour

Formal Support for Feature Specification

- considerable research effort
  on feature composition operators
- FIREworks project
  (Feature Interactions in Requirements Engineering)
  - various feature operators proposed and investigated
- "feature-oriented programming"
- based on the superimposition idea by Katz
- analytical complexity:
  too big for tools for real systems

Superimposition

- by Katz [Kat93]
- approach:
  - base system
  - textual increments
  - composition operator
- problem:
  - increments have defined interface,
    base system has not
  - increment can invalidate arbitrary assumptions about base system

The CoRE Method

- based on four-variable model and SCR
- groups the variables into classes
- developed during the early 1990's
- no explicit family support, but maybe a good base for it
- no formal syntax and semantics
- no tool support

Families of CSP-OZ Specifications

key ideas:

- *maintain all variants together*
  - generate specific member automatically as necessary
- *document information needed for changes*
  - dependence of requirements
  - what is the core of a feature

Constraint-Oriented Specification

- features closely interrelated
  - most refer to mode of connection
  - user interface: few, shared lexical events
    - ▷ system cannot be sliced by controlled events
- incrementally impose partial, self-contained constraints
- composition by logical conjunction

The Formalism CSP-OZ

- CSP-OZ demo: one very simple telephone
- CSP-OZ class inheritance for incremental constraints

Case Study on Telephone Switching Requirements

- black box specification of telephone switching
- attempt to incorporate new concepts
- details: see [Bre99]
  papers: see [Bre01b, Bre01a, Bre00c, Bre00a, Bre00a]

Grouping Classes into Features

the chapters of the requirements document:

1. Introduction
2. `feature` UserSpace
3. `feature` BasicConnection
4. `feature` VoiceChannel
5. `familymember` SpecificationA
6. `feature` ScreeningBase
7. `feature` BlackListOfDevices
8. `familymember` SpecificationB
9. `feature` BlackListOfUsers
10. `feature` FollowHumanConnectionForwarding
11. `familymember` SpecificationC
12. `feature` TransferUserRoleToAnotherHuman
13. `familymember` SpecificationD

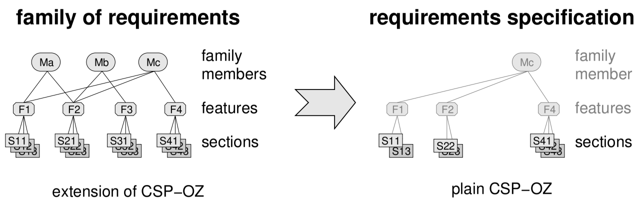
⋮ ⋮

Indices / Bibliography

The Feature Construct

- feature UserSpace
- feature BasicConnection
- familymember SpecificationB

Generating Family Members From a Family Document



Result of Family Member Generation

1. Introduction
2. `feature` UserSpace
3. `feature` BasicConnection
4. `feature` VoiceChannel
5. `feature` ScreeningBase
6. `feature` BlackListOfDevices
7. `familymember` SpecificationB

Indices / Bibliography

- family member composition chapter:
  part replaced

Controlled Non-Monotonous Changes

- feature ScreeningBase
- feature BlackListOfUsers
- feature FollowHumanConnectionForwarding
- familymember SpecificationC

Avoiding Feature Interactions

- introduced three notions explicitly
  - “telephone device”
  - “human”
  - “user role”
- consequences:
  - black list above:
    screens user roles, not devices
  - another black list feature:
    screens devices, not user roles
  - also two kinds of call forwarding
- no feature interaction screening–forwarding anymore

Detecting Feature Interactions by Type Checks

- *type rules*: part of the family extension of CSP-OZ
- syntactic rules → *syntactic errors*:
  - ◦ “remove” an “essential” class
  - ◦ feature of needed class not included
  - ◦ feature of “removed” class not included
  - ◦ another class still needs “removed” class
- heuristic syntactic rules → *syntactic warnings*:
  - ◦ class is marked both essential and changeable
  - ◦ class is “removed” twice

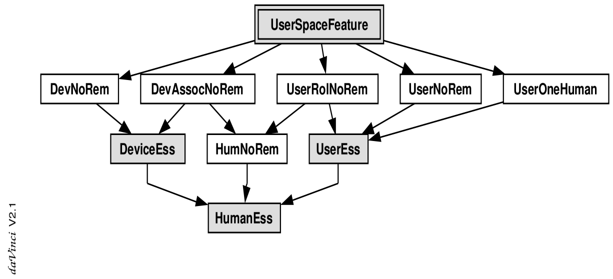
Feature Interactions Detected in Case Study

- no interactions between TCS and CF
  - ◦ no type errors detectable
- but other problems problems present:
  - ◦ both screening features “remove” the same section
  - ◦ type rules: warning!
  - ◦ manual inspection: contradiction
- resolution: another feature

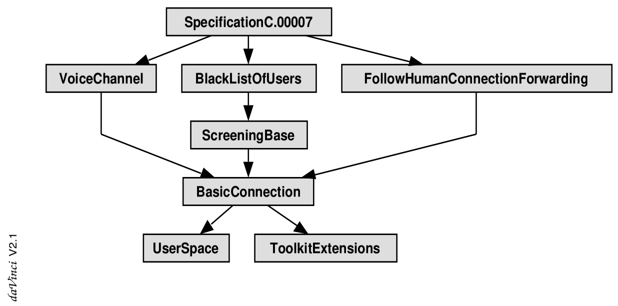
Documenting Dependences

- uses-relation for requirements:
  - ◦ use of previous definition
  - ◦ reliance on previous constraint
- documented by:
  - ◦ Z’s section “parents” construct
  - ◦ class inheritance (mapped to Z sections)
- if no relationship: identifiers out of scope

Sections of Feature UserSpace



Hierarchy of Features of SpecificationC



Hierarchical Requirements Specification

- a feature can build on other features
- in contrast to the Intelligent Network
- possible to have feature providing a common base

The Tool genFamMem 2.0

- extracts specifications in plain CSP-OZ from a family document,
- detects feature interactions by
  - ◦ additional type checks for families
  - ◦ heuristic warnings
- helps avoiding feature interactions by generating documentation on the structure of the family.
- available freely

Further Tools

- cspozTC
  - ◦ type checker for CSP-OZ
- daVinci
  - ◦ visualizes uses hierarchy graphs

Semantics of CSP-OZ Extension

- formal definition of language extension in [Bre00b]
  - understand details: need to know Object-Z and CSP

What Is Still To Do?

- more experience – extend case study further
- apply to other formalisms than CSP-OZ
  - necessary:
    constraint-oriented specification style
    and incremental refinement
  - already supported: CSP_Z and plain Z
- investigate relationship:
  families of requirements – families of programs

Families of CSP Test Specifications

- testing of embedded systems with RT-Tester tool
- RLC layer in UMTS protocol stack
- project with Bosch/Siemens Salzgitter
- requirements specification in CSP
- see [BrSc02]

- light-weight application of previous ideas
  - no consistency checks
  - no documentation generation
  - simple preprocessor for CSP plus method

Flexible Maintenance of Test Specification

- late changes to requirements
- variants of test suites:
  (a) adjust test coverage
    ▷ selected signal parameters
    ▷ stimuli: random → increased probabilities → deterministic
  (b) component / integration tests
    ▷ different protocol layers
    ▷ parallel instances of same layer
  (c) active / passive tests

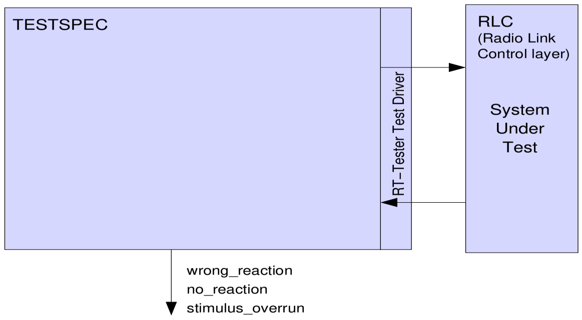
  ⇒ a family of test suites

Rules for Modularizing Requirements

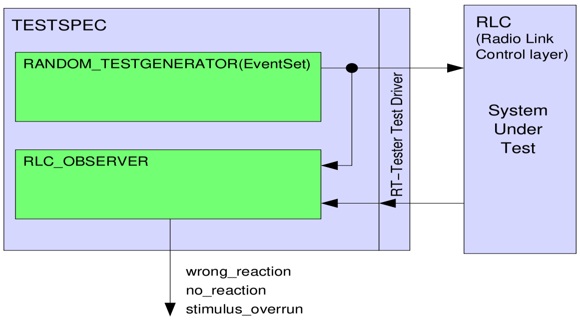
- separate: signature / behaviour of module
- identify requirements that will change together, put into one module

  specifically, separate:
  - tester specific issues / application
  - timer handling / application
  - protocol layers
  - stimulus generation / test observation

Separate: Test Stimulus Generation / Test Observation



Cont.: Separate: Test Stimulus Generation / Test Observation



Summary of Lecture

- safety-critical systems
  - quality does matter
- professional engineering
  - "blueprint before build"
    ▷ Chapter 2: what information in computer system documentation?
- embedded software systems
  - "ugly", strict interface constraints
    ▷ Chapter 1: rigorous description of requirements
  - interface changes all the time
    ▷ Chapter 3: decomposition into modules
    ▷ Chapter 4: families of systems

5. Appendix

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